#24/Appeal Brief 4/29/03

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of

Armbrust et al.

Serial No.: 09/666,325 Group Art Unit: 2811

Filed: September 21, 2000 Examiner: D. Kang

For: SELF-ALIGNED COPPER SILICIDE FORMATION FOR IMPROVED ADHESION/ELECTROMIGRATION

Assistant Commissioner for Patents

Washington, D.C. 20231

APPELLANTS' APPEAL BRIEF

Sirs:

Appellants respectfully appeal the final rejection of claims 15-34 in the final Office Action dated November 18, 2002 (hereinafter "Office Action"). A Notice of Appeal was timely filed on February 14, 2003.

I. REAL PARTY IN INTEREST

The real party in interest is International Business Machines Corp., Armonk, New York, assignee of 100% interest of the above-referenced patent application.

II. RELATED APPEALS AND INTERFERENCES

There are no other appeals or interferences known to Appellants, Appellants' legal representative or Assignee which would directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

III. STATUS OF CLAIMS

Claims 21-34, all of the claims pending in the application, are set forth fully in the attached appendix and stand rejected.

Appellants cancelled claims 1-14 in a Preliminary Amendment filed with the application on September 21, 2000. On April 21, 2001, Appellants added new claims 21-34 in response to a non-final Office Action dated January 2, 2001. In amendments dated January 15, 2002 and September 5, 2002, Appellants amended the independent claims 15, 21, and 29.

Appellants attempted to further amend claims 15, 21, 29, and cancel claim 27 in an Amendment after Final Rejection on January 16, 2003 solely for the purpose of eliminating informality rejections. However, the Office stated in an Advisory Action dated January 27,2003, that upon the filing of a Notice of Appeal, the proposed Amendments would not be entered. Appellants cancelled claims 15-20 in a Second Amendment after Final Rejection filed together with a Notice of Appeal on February 14, 2003. There was no indication that the February 14, 2003 Amendment was not entered and therefore this appeal brief is being filed with the presumption that the February 14, 2003 Amendment canceling claims 15-20 was entered.

IV. STATEMENT OF AFTER-FINAL AMENDMENTS

Appellants attempted to amend claims 15, 21, 29, and cancel claim 27 in an Amendment after Final Rejection filed on January 16, 2003. However, the Office stated in an Advisory Action dated January 27, 2003 that, upon the filing an appeal, the Amendment filed on January 16, 2003 would not be entered.

As explained above, Appellants cancelled claims 15-20 in a Second Amendment after Final Rejection filed together with a Notice of Appeal dated February 14, 2003. The claims shown in the appendix are shown in their amended form as of the February 14, 2003 Amendment.

V. SUMMARY OF THE INVENTION

Conventional methods for improving adhesion between interior copper wiring layers and adjacent insulating layers do not provide sufficient reliability of the terminal layer (e.g., the C4 layer) over the last metalization (LM) layer. The invention solves this problem increasing the thickness of the silicide layer above 10%, despite the fact that the prior art requires that the silicide thickness be less than 10%. For example, see the well-known teaching that silicide layers should comprise less than 10% of the copper silicide metallurgy in order to avoid resistivity problems (see the applied Filipiak reference (column 5, line 62-66), discussed below, and page 2, lines 5-15 of the application, both of which clearly explain this conventional 10% limitation).

Special problems exist with the adhesion of the last metalization layer (bonding pad) because the last metalization layer is subject to higher levels and different forms of stress than are the other metalization lawyers within the structure. For example, the last metalization is often physically connected to a solder ball terminal layer which is used to make electrical and physical contact to exterior structures. The exterior structure moves differently (through physical movement) and may have different thermal coefficients of expansion which tends to place high levels of stress (including shearing forces) on the last metalization layer. Therefore, delamination of the silicon nitride from the last metalization layer is more common than delamination within the semiconductor structure. Conventional solutions to this problem involve forming additional masking levels and patterning addition non-copper layers to reduce the stress between the copper and LM nitride. These solutions are costly, add significant cycle time and do not directly address the weak Cu-nitride interface which is responsible for the LM delamination.

The invention reduces such delamination by forming the silicide layer over the last metalization layer to generally at least 10-20% the thickness of the LM layer. This extensive silicide formation is used at the LM level to resolve the copper/nitrite adhesion issues discussed above. Conventional teachings limit the silicide to under 10% of metal wiring layers because silicide in excess of 10% increases resistivity unacceptably (see page 2, lines 5-15 of the application). However, the inventors discovered that because the last metalization layer generally comprises very thick metallurgy, it is substantially

less sensitive to resistivity shifts. Thus, with the invention the resistivity problems that occur with conventional copper silicide (CuSi) systems when the silicide exceeds the prior art 10% limit are avoided. The improved surface coverage provided by the invention enables less resistivity shift per percent thickness of LM layer formation.

More specifically, the independent claims define a structure that includes a silicide region of between 10% and 20% for the bonding pad using the language "wherein an upper 10% to 20% of said bonding pad comprises a silicided surface" (independent claims 21 and 29). In addition, the independent claims explain that the thickness of the uppermost layer reduces sensitivity to the resistivity shifts that are associated with the silicide surface using the language "wherein a thickness of said uppermost layer reduces sensitivity to resistivity shifts associated with said silicided surface" (independent claims 21 and 29). To the contrary, the applied prior art references teach that the silicide should be less than 10%.

VI. ISSUES PRESENTED FOR REVIEW

The issues presented for review by the Board of Patents Appeals and Interferences are whether claims 21-34 suffer from informalities under 35 U.S.C. §112, second paragraph, and whether claims 21-24, and 27-32 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Ngo; whether claims 25-26, and 33-34 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Ngo in view of Ohashi; whether claims 21-24, and 27-32 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Filipiak; and whether claims 25-26, and 33-34 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Filipiak in view of Dass.

VII. GROUPING OF THE CLAIMS

As supported by the following arguments, the claims are each independently patentable and do not stand or fall together. More specifically, the dependent claims are patently distinct from the independent claims from which they depend because each dependent claim defines additional features which are not defined in the independent

claims or which are defined more broadly in the independent claims. As discussed in greater detail below, the features defined by the dependent claims are not merely illustrations or examples but include patentable features which prevent the dependent claims from standing or falling with their associated independent claim.

VIII. ARGUMENT

A. The 35 U.S.C. §112, Second Paragraph, Rejection

Appellants initially note that the Board's time and effort needed to consider the issues regarding 35 U.S.C. § 112 were necessitated only by the Patent Office and it has been Appellants' intention and effort to avoid having the Board review 35 U.S.C. § 112 matters. As explained in greater detail below, not only do the 35 U.S.C. § 112 rejections lack merit, Appellants conceded the issue to the Office by making the amendments required to overcome the rejections. However, the Office refused to enter the January 16, 2003 Amendment presented by the Appellants, even though Appellants only offered the amendment so as to reduce the number of issues on appeal. The amendments offered by Appellants merely substituted synonymous wording in the claims and did not define new elements. Therefore, the proposed amendments clearly did not raise a new issue and would not require further consideration, but instead only would reduce the number of issues on appeal. The Amendment clearly should have been entered and it was an error on the part of the Office to refuse entry.

Thus, Appellants submit that the burden placed upon the Board by this portion of the appeal rests solely upon the Patent Office as it has been, and continues to be Appellants' position to avoid having the Board review the 35 U.S.C. § 112 matters. As explained above, Appellants attempted to amend claims 21 and 29 in order to eliminate the 35 U.S.C. §112 rejections in an after final amendment dated January 16, 2003. These Amendments were proposed in order to materially reduce or simplify the issues on appeal by eliminating the 35 U.S.C. § 112 rejections. However, the Office refused to enter the January 16, 2003 Amendment. Therefore, the appealed claims stand as amended in the September 5, 2002 Amendment. It is Appellants' position that the Board is unnecessarily

required to invest time and resources evaluating the 35 U.S.C. § 112 rejections only because of the Office's failure to enter the January 16, 2003 Amendment.

With respect to the merits of the rejection, the Office Action argues that claims 21-31 stand rejected under 35 U.S.C. §112, second paragraph, as being indefinite for failing to point out and distinctly claim the subject matter which Appellants regard as the invention. In claims 21 and 29, the phrase "a thickness of said upper most layer reduces sensitivity to resistivity shifts associated with said silicide surface" is rejected as being unclear because the "thickness is not defined by the claim" (Office Action page 2).

Appellants first submit that the rejection is improper because it is unclear. Does the language in the Office Action "thickness is not defined by the claim" require that a certain measurement be inserted, or potentially could this rejection be questioning what the term "thickness" means. The Office Action simply does not provide any guidance as to why such language is unclear other than to say that it is "not defined." Appellants submit that the rejection is technically defective because the meaning of the rejection cannot be readily determined.

Appellants further submit that the term "thickness" does not have previous antecedent basis in the claims. Therefore Appellants used to the article "a" to precede the definition of the term in the claims. To the contrary, if Appellants had recited "said thickness" then Appellants would agree with the rejection that the term and not been previously defined. However, since Appellants used the article "a" this indicates that the term is being defined for the first time and was not defined previously. In addition, Appellants note that the language rejected is used with a clause that begins with the term "wherein" that indicates additional explanation of a previously defined feature follows. Indeed, this portion of the claims is not attempting to define what the "thickness" of the uppermost layer is, but instead is intended to define that the thickness of the uppermost layer reduces sensitivity to the undesirable resistivity shifts associated with the thicker silicided surface. Appellants submit that this language very clearly describes the nature of the thickness of the uppermost layer and defines that the invention is further limited to such situations where the thickness of the uppermost layer eliminates resistivity shifts problems. Therefore, Appellants submit that the language is clear and concise and fully

defined and that the rejection should be withdrawn on its merits. In view of the foregoing, the Board is respectfully requested to reconsider and withdraw this rejection.

In addition, claims 21 and 29 stand rejected based on insufficient antecedent basis for the limitation "said uppermost layer." Appellants agree with this portion of the rejection and also agree to amend the claims to recite "top level of metallurgy" in place of "uppermost layer" to eliminate this rejection (as was attempted and the January 16, 2003 Amendment) to place the application in proper condition for allowance after the prior art rejections discussed below are reversed by the Board.

B. The Prior Art Rejections

1. The Rejection Based on Ngo

a. The Position in the Office Action

With respect to the rejection of claims 21-22 and 27-30, the Office Action states the following:

> Ngo et al. teaches a semiconductor device comprising (Fig. 5): an exterior surface having a top level of metallurgy (13 A); and an interior having at one internal level of metallurgy (12), wherein said top level of metallurgy is thicker than said internal level of metallurgy, wherein the top level of metallurgy comprises a silicide layer (40), wherein said top level of metallurgy comprises copper.
>
> Ngo et al. does not expressly teach the copper interconnection layer for a bonding pad. However, it would have been obvious for the same reason as given for the rejection of claim 15 (see above).
>
> Ngo et al. does not expressly teach the copper silicide layer comprises 10% to 20% of a thickness of the top level of metallurgy. However, Ngo et al. teaches a copper suicide layer has a thickness of about 10 to about 1000, which is in the inventive thickness ranges where the thickness of silicide layer is approximately 1000 in this application (page 8, line 21). Therefore, the copper silicide layer of Ngo would have a 10% to 20% of a thickness of the top level of metallurgy since both silicide layers have a same thickness.
>
> Furthermore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to select the thickness of

> silicide layer, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. In re Aller, 105 USPQ 233.
>
> Ngo et al. does not expressly teach a thickness of said uppermost layer reduces sensitivity to resistivity shifts associated with said silicide layer. However, this feature is inherent because a structure of Ngo's device is identical with the claimed structure.

Regarding the rejection of claims 23-24 and 31-32, the Office Action states the following:

> Ngo et al. teaches the method of cleaning of top level of metallurgy by applying a hydrogen-containing plasma prior to formation of silicide surface (Col.5, line 60 - Col,6, line8) to make top level of metallurgy is free of oxides and silicide islands."

b. Appellants' Position

i. Independent claims 21 and 29

Ngo does not disclose a specific thickness of silicide and cannot be modified to teach a thickness of silicide greater than 10% because other applied prior art references and the background section of the application teach against such modification. Therefore, Ngo does not teach or suggest the following claim limitation "an upper 10% to 20% of said bonding pad comprises a silicided surface" as defined by independent claims 21 and 29.

More specifically, the Office Action argues that Ngo discloses that the copper silicide layer could comprise 10%-20% of the thickness of the top level of the metallurgy. However, Ngo is silent regarding the percentage that the copper silicide represents of the overall copper interconnect 13A. Indeed, the Office Action admits that Ngo does not expressly teach that copper silicide layer comprises 10%-20% of the thickness of the top level of metallurgy (Office Action, p. 4, lines 10-11 (4th paragraph)). Instead, the Office Action proposes that since Ngo discloses that the silicide layer can be 1000 A thick and that the application states that the silicide layer can be 1000 A thick that Ngo, therefore, discloses that the copper silicide layer in Ngo must be 10%-20% of the thickness of the

top level of metallurgy. Appellants respectfully disagree with this conclusion, especially considering that Ngo does not disclose the thickness of the top level of metallurgy 13A. Since the thickness of the top level of metallurgy 13A is not disclosed, the percentage that the silicide layer represents of the top level of metallurgy cannot be calculated. In other words, Ngo clearly does not disclose any information that would allow one to know the percentage that the silicide layer represents of the entire thickness of the top level of metallurgy.

Further, there is nothing in Ngo that would lead one ordinarily skilled in the art to break away from the well-known teaching that silicide layers should comprise less than 10% of the copper silicide metallurgy in order to avoid resistivity problems (see the applied Filipiak reference (column 5, line 62-66), discussed below, and page 2, lines 5-15 of the application, both of which clearly explain this conventional 10% limitation). for example, this section of Filipiak reference states:

> As a general rule, the thickness of a silicide layer should not exceed ten percent of the total thickness of the copper. For example, in reference to FIG. 5, a silicide layer 32 is formed on copper interconnects 30 in accordance with the previously described process. Preferably, the thickness of layer 32, indicated in FIG. 5 as `X`, should not be greater than ten percent of the total thickness of the copper interconnect, indicated in FIG. 5 as `Y`. A reason for limiting the thickness of the silicide layer to less than ten percent of the total copper thickness is that silicidation degrades the resistivity of the copper interconnect.

This is a very strong teaching regarding the necessity to restrict the silicide to less than 10% of the overall thickness of the metallurgy. Such teaching directly contradicts the proposed modification of Ngo and clearly demonstrates why one ordinarily skilled in the art would not have modified Ngo as proposed in the Office Action. Thus, it is Appellants' position that one would not have modified Ngo to include a teaching that the silicide should exceed 10% of the top level of metallurgy. There simply is no basis for such a modification, and to the contrary, the prior art of record and the application teach away from such a modification. Therefore, Appellants submit that the rejection is defective because it improperly modifies the reference and the invention is patentable

over the reference because the reference does not disclose the claimed features of the invention.

More specifically, Appellants submit that Ngo does not teach that the "upper 10% to 20% of said bonding pad comprises a silicided surface" as defined by independent claims 21 and 29. Appellants' position is supported by the fact that the Office Action admits that Ngo does not disclose that the silicide region could comprise 10% to 20% of the upper layer of metallurgy, and that the specification and the applied Filipiak reference teaches away from modifying Ngo to include any such teaching.

Therefore, Appellants respectfully submit that independent claims 21 and 29 are patentable over Ngo. In view of the forgoing, the Board is respectfully requested to reconsider and withdraw this rejection.

ii. Independent Patentability of Dependent Claims 22-24, 27, 28, and 30-32

The following discussion demonstrates not only that Ngo does not teach or suggest the invention defined by the dependent claims, but also that the dependent claims are independently patentable over their associated independent claims and do not stand or fall with their associated independent claims.

With respect to dependent claims 22 and 30, that define that the bottom 80% to 90% of the bonding pad is free of silicide, Ngo does not teach or suggest any specific silicide amount (this is as shown above). Therefore, Ngo cannot teach or suggest what percentage is free of the silicide. Therefore, dependent claims 22 and 30 are patentable over Ngo. Further, dependent claims 22 and 30 are independently patentable over independent claims 21 and 29 because these features are in addition to the features defined by the independent claims and are shown to be novel (not being taught or suggested by the prior art of record). Thus, dependent claims 22 and 30 are independently patentable over Ngo.

Dependent claims 23, 24, 31, and 32 define that the silicided surface is free of oxides and silicide islands because the bonding pad is cleaned by applying either an ammonia plasma or a hydrogen plasma prior to formation of said silicided surface. The

Office Action refers to column 5, line 60-column 6, line 8 as teaching a cleaning process. Then, the Office Action concludes that such a cleaning process must necessarily prevents oxides and silicide islands from forming. However, a close reading of column 5, line 60-column 6, line 19 of Ngo merely discloses that a certain plasma is applied to the copper interconnect in order to create the silicide. There is no explanation of a specific cleaning process much less that this processing would eliminate oxides or silicide islands. Thus, while Ngo discloses the application of a plasma to the copper interconnect, there is no disclosure in Ngo that the silicide surface is free of oxides and silicide islands (as claimed) or that these features are produce by the claim cleaning process. To the contrary, the quoted section of Ngo merely states that a plasma is applied during the silicide process. Therefore, dependent claims 23, 24, 31, and 32 are patentable over Ngo principally because Ngo does not teach or suggest that the silicide surface would be free of oxides and silicide islands. The novelty of these features is independent from the features defined by the independent claims. The lack of oxides and silicide islands is an additional feature not contemplated or defined by the independent claims. Further, this feature is not taught or suggested by the applied prior art of record. Therefore, dependent claims 23, 24, 31, and 32 are also independently patentable over the independent claims.

Claim 27 defines that the top level of metallurgy is thicker than internal levels of metallurgy. Ngo does not teach or suggest that the thicker top level of metallurgy could include a silicide region that exceeded the conventional 10% limitation. Therefore, Ngo does not teach or suggest the invention defined by dependent claim 27. Claim 28 defines that the top level of metallurgy comprises copper. Ngo does not teach or suggest that the copper top level of metallurgy could include a silicide region that exceeded the conventional 10% limitation. Therefore, Ngo does not teach or suggest the invention defined by dependent claim 28.

Therefore, as shown above, the dependent claims are also each patentable over Ngo and are independently patentable from their associated independent claims and stand on their own. In view of the forgoing, the Board is respectfully requested to reconsider and withdraw this rejection.

2. The Rejection Based on Ngo in view of Ohashi

a. The Position in the Office Action

With respect to claims 25-26 and 33-34, the Office Action states the following:

> Ngo et al. teaches the semiconductor device comprises a silicon nitride layer (50) physically connected to said silicide surface. Ngo et al. does not expressly teach silicon nitride layer including an opening allowing direct electrical contact with solder terminal. However, Ohashi et al. teaches in Fig.76 a solder terminal (136) directly connected to copper bonding pad (M5). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to form the solder terminal on the copper interconnection of Ngo, which includes silicide surface, in order to facilitate electrical connection of the semiconductor structure with an external connector, such as modulator package substrate."

b. Appellants' Response

As shown above, Ngo is deficient in teaching the features defined by independent claims 21 and 29. The Office Action combines Ngo with Ohashi in an argument that dependent claims 25-26, and 33-34 are unpatentable. More specifically, the Office Action refers to Ohashi for teaching an opening allowing direct electrical contact with a solder terminal. Appellants respectfully disagree that one ordinarily skilled in the art would have combined Ngo with Ohashi because there is no suggestion in either reference (or any other prior art of record) for this combination. Instead, the only motivation for such a combination lies in Appellants' disclosure. Therefore, Appellants initially note that the rejection is defective because the Examiner has failed to set forth a prime facia case of obviousness. The rejection should be withdrawn on this basis alone.

Notwithstanding the foregoing, even if one ordinarily skilled in the art had made the combination of references proposed in the Office Action, the combination would not teach or suggest the invention as defined by independent claims 21 and 29 principally because no prior art of record teaches or suggests that the thickness of the top level of

metallurgy reduces the sensitivity to resistivity shifts, or that the silicide can exceed 10% of the thickness of the metallurgy, as the claimed invention does. Therefore, Appellants respectfully submit that independent claims 21 and 29 are patentable over the proposed combination of references.

In addition, claims 25, 26, 33, and 34 define that the thickness of the silicide surface increases the adhesion between the terminal on the bonding pad with a terminal that can be either lead or solder. This feature of the invention produces many of the invention's advantages. These claims relate to the invention's ability to reduce delamination by forming the silicide layer over the last metalization layer to generally at least 10-20% the thickness of the bonding layer. This extensive silicide formation is used at the bonding level to resolve copper/nitrite adhesion issues. Ngo and Ohashi do not contradict the clear conventional teaching that the silicide be limited to under 10% of metal wiring layers because silicide in excess of 10% increases resistivity unacceptably (see page 2, lines 5-15 of the application). However, the inventors discovered that because the last metalization layer generally comprises very thick metallurgy, it is substantially less sensitive to resistivity shifts. Thus, with the invention the resistivity problems that occur with conventional copper silicide (CuSi) systems when the silicide exceeds the prior art 10% limit are avoided. The improved surface coverage provided by the invention enables less resistivity shift per percent thickness of bonding layer formation.

Thus, even if one ordinarily skilled in the art had referred to both Ngo and Ohashi, they would not have arrived at the features of the invention defined by dependent claims 25, 26, 33, and 34. Further, such claims are independently patentable over their respective independent claims because these novel features are patentable on their own and shown by their lack of teaching in the prior art of record. In view the forgoing, the Board is respectfully requested to reconsider and withdraw this rejection.

3. The Rejection Based on Filipiak

a. The Position in the Office Action

Regarding claims 21-22, 27-28 & 29-30, the Office Action states the following:

> "Filipiak et al. teaches a semiconductor device comprising (Fig. 5):
>
> An exterior surface having a top level of metallurgy; an interior having at least one internal level of metallurgy, wherein said top level of metallurgy is thicker than said internal level of metallurgy,
>
> wherein the exterior surface comprises a silicide layer,
>
> wherein said top level of metallurgy comprises copper; and a thickness of said uppermost layer reduces sensitivity to resistivity shifts associated with said silicide layer.
>
> Filipiak et al. does not expressly teach the copper interconnection layer for a bonding pad. It would have been obvious for the same reason as given for the rejection of claim 15. Filipiak et al. does not teach the silicide thickness which is in the ranges 10% to 20% of the total thickness of the copper interconnect layer. However, Filipiak et al. mentioned the thickness of silicide layer can be changed depend on the application of device (Col.5, line 63 - Col.6, line 6). Thus, it would have been obvious to one of ordinary skill in the art at the time the invention was made to select the thickness of silicide layer, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. In re Aller, 105 USPQ 233.

Regarding claims 23-24 & 31-32, the Office Action states the following:

> Filipiak et al. does not teach the method of cleaning of uppermost layer by applying a hydrogen-containing plasma prior to formation of silicide surface (Col.5, line 60 - Col.6, line8). This is a product-by-process limitation. Even though product-by-process claims are limited by and defined by the process, determination of patentability is based on the product itself. The patentability of a product does not depend on its method of production. If the product in the product-by-process claim is the same as or obvious from a product of the prior art, the claim is unpatentable even though the prior product was made by a different process. In re Thorpe, 777F. 2d 695,698 USPQ 964, 966 (Fed,

Cir, 1985). See also MPEP 2113. Moreover, an old or obvious product produced by a new method is not a patentable product, whether claim in "product by process" claim or not."

b. Appellants' Response

i. Independent claims 21 and 29

Filipiak expressly teaches that the silicide should not exceed 10% of the total thickness of of metal layer. Therefore, Filipiak cannot be modified to teach that "an upper 10% to 20% of said bonding pad comprises a silicided surface" (as defined by independent claims 21 and 29) because such a modification of Filipiak would be directly contrary to its explicit teachings.

The disclosure in Filipiak is consistent with the description of the problems associated with the prior art (see page 2, lines 5-15 of the application). More specifically, the prior art teaches that the thickness of a silicide layer should not exceed 10% of the total thickness of the metal layer. Filipiak is consistent with this teaching where it states that the thickness of the silicide layer 32 should not be greater than 10% of the total thickness of the copper interconnects as shown in Figure 5 (column 5, line 62-66). Filipiak explicitly explains that the reason for limiting the thickness of the silicide layer to less than 10% of the total copper thickness is that the silicidation degrades the resistivity of the copper interconnect (column 5, line 66-column 6, line 1). Filipiak states that where resistivity is not an important issue silicide thickness may not be as tightly controlled.

In the claimed invention, the thickness of the uppermost layer reduces sensitivity to resistivity shifts associated with the silicided surface. It is Appellants' position that this is directly contrary to the claimed invention because avoiding any increase in resistivity is very important. Indeed, page 6, lines 4-10 of the application explains that the invention avoids delamination without increasing resistivity. Therefore, one of the clear goals of the application is to avoid delamination without affecting resistivity (also see page 4, lines 5-13 of the application). Therefore, in the claimed invention, resistivity is an important issue in that reducing sensitivity to resistivity shifts is a claimed feature of independent

claims 21 and 29 which state "wherein a thickness of said uppermost layer reduces sensitivity to resistivity shifts associated with said silicided surface." With respect to the claimed invention (e.g., where resistivity is an important issue), the teachings in Filipiak require that the silicide layer not be greater than 10% of the total thickness of the interconnect.

In addition, the language in Filipiak relied upon for teaching the claimed 10%-20% silicide portion merely states that the "silicidation thickness may not need to be as tightly controlled." The meaning of this phrase cannot be known with certainty. The vagueness of this statement prevents the applied reference from teaching the explicit structure of 10%-20% silicide defined by the dependent claims. It is unclear whether the phrase "not need be as tightly controlled" in Filipiak means a 1% variation, 5% variation, 10% variation, or some other percentage variation. In any case, such language cannot be reasonably construed to meet a 100% variation as required by the 20% thickness in the extreme definition of the claim. Therefore, it is clear that such language did not contemplate the fundamental meaning of the invention, which was to substantially increase silicide thickness, when compared to the conventional 10% limitation, so as to decrease delamination without substantially altering resistivity. Therefore, it is also Appellants' position that the language relied upon in Filipiak does not allow modification of the structure to come into the realm of the claimed invention.

Contrary to the teachings in Filipiak, independent claims 21 and 29 define that the silicide surface is within the top 10-20% of the conductive layer. Therefore, since the claims define that resistivity is an important issue and that the silicide surface is outside the range required by Filipiak, Filipiak cannot be said to teach or suggest the invention.

With respect to the arguments in the Office Action that one ordinarily skilled in the art would have experimented outside the 10% range in order to arrive at Appellants' invention, Appellants note that Filipiak teaches one ordinarily skilled in the art not use a silicide thickness greater than 10%. Therefore, using the teachings in Filipiak, one ordinarily skilled in the art would not use a silicide layer of having a thickness greater than 10% where resistivity shifts are important (as in the claimed invention). The claimed invention breaks away from conventional teachings and includes a silicide layer in the range of 10-20%. Filipiak teaches away from the claimed invention by teaching

that the silicide layer should not be greater than 10% in situations where resistivity is important. Therefore, the arguments in the Office Action that Appellants merely discovered an optimum working range involving only routine skill are inappropriate considering that the prior art (Filipiak) teaches one ordinarily skilled in the art not to use ranges above 10% when resistivity issues are important.

Therefore, with respect to claims 21 and 29, that define a silicided surface in the upper 10% to 20% of the bonding pad, Appellants submit that such features are clearly not taught or suggested by Filipiak. Indeed, Filipiak teaches away from such claimed features. Appellants resolved resistivity issues according to the thickness of the uppermost layer. To the contrary, Filipiak teaches that one should limit the thickness of the silicide portion in order to control resistivity issues.

Thus, as shown above, Filipiak teaches away from the invention defined by independent claims 21 and 29. Therefore, the invention defined by independent claims 21 and 29 is patentable over Filipiak. In view the forgoing, the Board is respectfully requested to reconsider and withdraw this rejection.

ii. Independent Patentability of Dependent Claims 22-24, 27, 28, and 30-32

The following discussion demonstrates not only that Filipiak does not teach or suggest the invention defined by the dependent claims, but also that the dependent claims are independently patentable over their associated independent claims and do not stand or fall with their associated independent claims.

With respect to dependent claims 22 and 30, that define that the bottom 80% to 90% of the bonding pad is free of silicide, Filipiak explicitly requires that the silicide not be above 10% (this is as shown above). Therefore, Filipiak expressly teaches a different percentage of the portion that is free of the silicide. Therefore, dependent claims 22 and 30 are patentable over Filipiak. Further, dependent claims 22 and 30 are independently patentable over independent claims 21 and 29 because these features are in addition to the features defined by independent claims and are shown to be novel (not being taught or

suggested by the prior art of record). Thus, dependent claims 22 of 30 are independently patentable over Filipiak.

Dependent claims 23, 24, 31, and 32 define that the silicided surface is free of oxides and silicide islands because the bonding pad is cleaned by applying either ammonia plasma or a hydrogen plasma prior to formation of said silicided surface. The Office Action admits that Filipiak does not teach or suggest a cleaning process and instead argues that the claims include product by process limitations. However, Appellants submit that defining that the surface is "free of oxides and silicide islands" is a structure feature and not a mere product process limitation. Since Filipiak does not disclose any cleaning process, the structure produced by the Filipiak disclosure may include oxides and silicide islands. Therefore, Appellants submit that these dependent claims defined yet another structural difference between the claimed invention and the Filipiak reference. There is no explanation of a specific cleaning process in Filipiak, much less that this processing would eliminate oxides or silicide islands. Thus, there is no disclosure in Filipiak that the silicide surface is free of oxides and silicide islands (as claimed) or that these features are produce by the claimed cleaning process. Therefore, dependent claims 23, 24, 31, and 32 are patentable over Filipiak principally because Filipiak does not teach or suggest that the silicide surface would be free of oxides and silicide islands. The novelty of these features is independent from the features defined by the independent claims. The lack of oxides and silicide islands is an additional feature not contemplated or defined by the independent claims. Further, this feature is not taught or suggested by the applied prior art of record. Therefore, dependent claims 23, 24, 31, and 32 are also independently patentable over the independent claims.

Claim 27 defines that the top level of metallurgy is thicker than the internal levels of metallurgy. Filipiak does not teach or suggest that the thicker top level of metallurgy could include a silicide region that exceeded the conventional 10% limitation. Therefore, Filipiak does not teach or suggest the invention defined by dependent claim 27. Claim 28 defines that the top level of metallurgy comprises copper. Filipiak does not teach or suggest that the copper top level of metallurgy could include a silicide region that exceeded the conventional 10% limitation. Therefore, Filipiak does not teach or suggest the invention defined by dependent claim 28.

Therefore, as shown above, the dependent claims are also each patentable over Filipiak and are independently patentable from their associated independent claims and stand on their own. In view of the forgoing, the Board is respectfully requested to reconsider and withdraw this rejection.

2. The Rejection Based on Filipiak in view of Dass

a. The Position in the Office Action

With respect to the rejection of claims 25-26, and 33-34, the Office Action states the following:

> Filipiak et al. does not teach the semiconductor device further comprises a silicon nitride layer (34) physically connected to said silicide layer and a solder terminal electrically connected to bonding pad. However, Dass et al. teaches in Fig.21 the solder terminal (270) connected to bonding pad and a silicon nitride (245). Thus, it would have been obvious to one of ordinary skill in the art at the time the invention was made to form the solder terminal in order to facilitate electrical connection of the semiconductor structure with an external connector, such as modulator package substrate."

b. Appellants' Response

Appellants respectfully disagree that one ordinarily skilled in the art would have combined Filipiak with Dass because there is no suggestion in either reference (or any other prior art of record) for this combination. Instead, the only motivation for such a combination lies in Appellants disclosure. Therefore, Appellants initially note that the rejection is defective because the Examiner has failed to set forth a prime facia case of obviousness. The rejection should be withdrawn on this basis alone.

Notwithstanding the foregoing, even if one ordinarily skilled in the art had made the combination of references proposed in the Office Action, the combination would not teach or suggest the invention as defined by independent claims 21 and 29 principally because no prior art of record teaches or suggests that the thickness of the top level of

metallurgy reduces the sensitivity to resistivity shifts, or that the silicide can exceed 10% of the thickness of the metallurgy, as the claimed invention does. Therefore, Appellants respectfully submit that independent claims 21 and 29 are patentable over the proposed combination of references.

The Dass reference is only utilized in the Office Action to show the use of tin solder when connecting to a bonding pad. Dass is silent regarding siliciding the upper layer of the bonding pad. Therefore, Dass does not cure the deficiencies of Filipiak as discussed above. Thus, even if one ordinarily skilled in the art had combined Dass and Filipiak, the proposed combination would not teach or suggest the invention as defined by independent claims 21 and 29, as discussed above. Therefore, these independent claims are patentable over the proposed combination of references.

Further, not only do Filipiak and Dass not teach or suggest the invention defined by the dependent claims, but also the dependent claims are independently patentable over their associated independent claims and do not stand or fall with their associated independent claims.

In addition, claims 25, 26, 33, and 34 define that the thickness of the silicide surface increases the adhesion between the terminal on the bonding pad with a terminal can be either lead or solder. This feature of the invention produces many of the invention's advantages. These claims relate to the invention ability to reduce delamination by forming the silicide layer over the last metalization layer to generally at least 10-20% the thickness of the bonding layer. This extensive silicide formation is used at the bonding level to resolve copper/nitrite adhesion issues. Filipiak and Dass do not contradict the clear conventional teaching that the silicide the limited to under 10% of metal wiring layers because silicide in excess of 10% increases resistivity unacceptably (see page 2, lines 5-15 of the application). However, the inventors discovered that because the last metalization layer generally comprises very thick metallurgy, it is substantially less sensitive to resistivity shifts. Thus, with the invention the resistivity problems that occur with conventional copper silicide (CuSi) systems when the silicide exceeds the prior art 10% limit are avoided. The improved surface coverage provided by the invention enables less resistivity shift per percent thickness of bonding layer formation.

Thus, even if one ordinarily skilled in the art had referred to both Filipiak and Dass, they would not have arrived at the features of the invention defined by dependent claims 25, 26, 33, and 34. Further, such claims are independently patentable over their respective independent claims because these novel features are patentable on their own as shown by their lack of teaching in the prior art of record. In view the forgoing, the Board is respectfully requested to reconsider and withdraw this rejection.

IX. CONCLUSION

Only one of the four applied prior art references (Filipiak) actually teaches a recommended silicide percentage thickness for copper wiring. The Office Action admits that Ngo does not teach a recommended percentage thickness of silicide, and the remaining applied references Ohashi and Dass are referenced for unrelated features such as the use of soldered terminals (and clearly do not include any such teachings).

However, it is Appellants' position that the Filipiak reference teaches away from the claimed invention by explicitly requiring that the silicide be less than 10% of the wiring thickness in situations where resistivity is important. In column 5, line 63-65, Filipiak expressly states that the thickness of the silicide layer should not be greater than 10% of the total thickness of the copper interconnect.

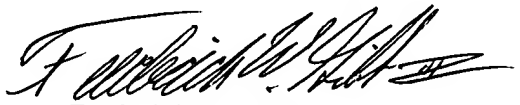
The Office Action points to language in column 6, lines 1-4 of Filipiak and argues that such language allows the silicide thickness to exceed the 10% limitation. However, the language referred to in column 6 explains that "in other applications where resistivity is not an important issue" the silicide thickness may not be as tightly controlled. It is Appellants' position that this is directly contrary to the claimed invention because avoiding any increase in resistivity is very important. Indeed, page 6, lines 4-10 of the application explains that the invention avoids delamination without increasing resistivity. Therefore, one of the clear goals of the application is to avoid delamination without affecting resistivity (also see page 4, lines 5-13 of the application). Further, in the claimed invention, resistivity is an important issue in that reducing sensitivity to resistivity shifts is a claimed feature of independent claims 21 and 29 which state "wherein a thickness of said uppermost layer reduces sensitivity to resistivity shifts

associated with said silicided surface." Thus, with respect to the claimed invention (e.g., where resistivity is an important issue), the teachings in Filipiak require that the silicide layer not be greater than 10% of the total thickness of the interconnect.

In addition, the language in Filipiak relied upon for teaching the claimed 10%-20% silicide portion merely states that the "silicidation thickness may not need to be as tightly controlled." The meaning of this phrase cannot be known with certainty. The vagueness of this statement prevents the applied reference from teaching the explicit structure of 10%-20% silicide defined by the dependent claims. It is unclear whether the phrase "not need be as tightly controlled" in Filipiak means a 1% variation, 5% variation, 10% variation or some other percentage variation. With the previous explicit 10% maximum, any "variation" would still have to be below the 10% to be consistent with the teachings in Filipiak. In any case, such language cannot be reasonably construed to meet a 100% variation as required by the 20% thickness in the extreme definition of the claim. Therefore, it is clear that such language did not contemplate the fundamental meaning of the invention, which was to substantially increase silicide thickness, when compared to the conventional 10% maximum limitation, so as to decrease delamination without substantially altering resistivity. Therefore, it is also Appellants' position that the language relied upon in Filipiak does not allow modification of the structure to come into the realm of the claimed invention.

Thus, the Board is respectfully requested to remove the rejections of claims 21-34. Please charge any deficiencies and credit any overpayments to Attorney's Deposit Account number 09-0456.

Respectfully submitted,



Frederick W. Gibb, III
Registration No. 37,629

Date: 4/14/03

McGinn & Gibb, PLLC
2568-A Riva Road
Suite 304
Annapolis, MD 21401
301-261-8071
Customer No. 29154

APPENDIX

21. A semiconductor device comprising:

an exterior surface having a top level of metallurgy,

wherein an exposed portion of said top level of metallurgy comprises a bonding pad,

wherein an upper 10% to 20% of said bonding pad comprises a silicided surface, and

wherein a thickness of said uppermost layer reduces sensitivity to resistivity shifts associated with said silicided surface.

22. The semiconductor device in claim 21, wherein a bottom 80% to 90% of said bonding pad is free of silicide.

23. The semiconductor device in claim 22, wherein said silicided surface is free of oxides and silicide islands.

24. The semiconductor device in claim 23, wherein, prior to formation of said silicided surface, said bonding pad is cleaned by applying one of an ammonia plasma and a hydrogen plasma to make said bonding pad free of said oxides and silicide islands.

25. The semiconductor device in claim 21, further comprising a terminal connected to said bonding pad, wherein a thickness of said silicided surface increases adhesion between said terminal and said bonding pad.

26. The semiconductor device in claim 25, wherein said terminal comprises one of a lead and tin solder.

27. The semiconductor device in claim 21, further comprising at least one internal level of metallurgy within an interior of said semiconductor device, wherein said top level of metallurgy is thicker than said internal level of metallurgy.

28. The semiconductor device in claim 21, wherein said top level of metallurgy comprises copper.

29. A semiconductor chip comprising:

an exterior surface having a top level of metallurgy; and

an interior having at least one internal level of metallurgy,

wherein said top level of metallurgy is thicker than said internal level of metallurgy,

wherein an exposed portion of said top level of metallurgy comprises a bonding pad,

wherein an upper 10% to 20% of said bonding pad comprises a silicided surface, and

wherein a thickness of said uppermost layer reduces sensitivity to resistivity shifts associated with said silicided surface.

30. The semiconductor device in claim 29, wherein a bottom 80% to 90% of said bonding pad is free of silicide.

31. The semiconductor device in claim 30, wherein said bonding pad is free of oxides and silicide islands.

32. The semiconductor device in claim 31, wherein, prior to formation of said silicided surface, said bonding pad is cleaned by applying one of an ammonia plasma and a hydrogen plasma to make said bonding pad free of said oxides and silicide islands.

33. The semiconductor device in claim 29, further comprising a terminal connected to said bonding pad, wherein a thickness of said silicided surface increases adhesion between said terminal and said bonding pad.

34. The semiconductor device in claim 33, wherein said terminal comprises one of a lead and tin solder.

$AF/2811

TRANSMITTAL OF APPEAL BRIEF (Large Entity)

Docket No. BU998110DIV

In Re Application Of:
Armbrust et al.

Serial No.	Filing Date	Examiner	Group Art Unit
09/666,325	September 21, 2000	D. Kang	2811

Invention: **SELF-ALIGNED COPPER SILICIDE FORMATION FOR IMPROVED ADHESION/ELECTROMIGRATION**

TO THE ASSISTANT COMMISSIONER FOR PATENTS:

Transmitted herewith in triplicate is the Appeal Brief in this application, with respect to the Notice of Appeal filed on **February 14, 2003**

The fee for filing this Appeal Brief is: **$320.00**

☐ A check in the amount of the fee is enclosed.

☒ The Commissioner has already been authorized to charge fees in this application to a Deposit Account. A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit an overpayment to Deposit Account No. **09-0456**
A duplicate copy of this sheet is enclosed.

Signature

Dated: **April 14, 2003**

Frederick W. Gibb, III Reg. No. 37,629
McGinn & Gibb, PLLC
2568-A Riva Road
Suite 304
Annapolis, MD 21401
301-261-8071
Customer No. 29154

I certify that this document and fee is being deposited on 4/14/03 with the U.S. Postal Service as first class mail under 37 C.F.R. 1.8 and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

Signature of Person Mailing Correspondence

Frederick W. Gibb, III

Typed or Printed Name of Person Mailing Correspondence

cc: